PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04B 7/005 | A2

(11) International Publication Number: **WO 00/64071**

(43) International Publication Date: 26 October 2000 (26.10.00)

(21) International Application Number: PCT/US00/10238

(22) International Filing Date: 18 April 2000 (18.04.00)

(30) Priority Data:
09/296,055 21 April 1999 (21.04.99) US

(71) Applicant *(for all designated States except US)*: COMSPACE CORPORATION [US/US]; Suite 100, 955 Freeport Parkway, Coppell, TX 75019–4415 (US).

(72) Inventors; and

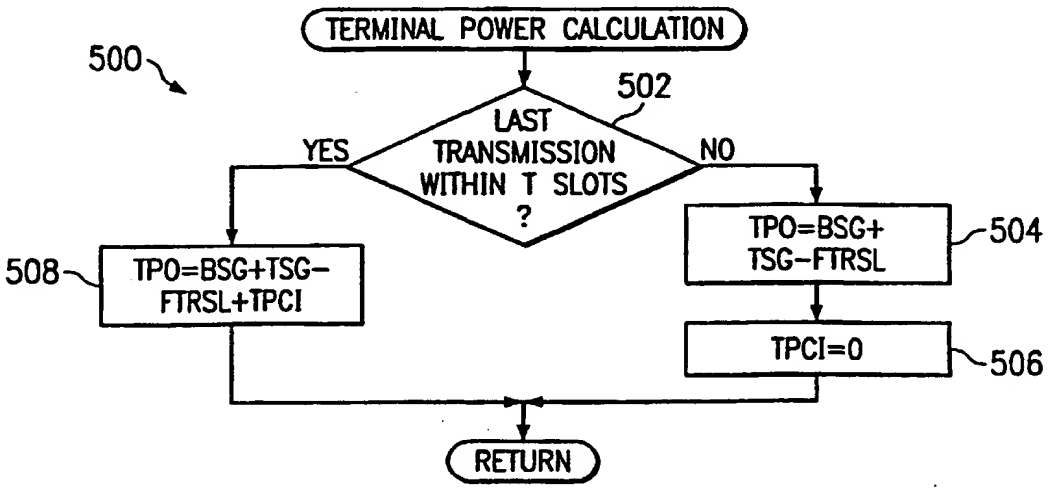
(75) Inventors/Applicants *(for US only)*: BARTELME, Joseph, Peter [US/US]; 2111 Lakeridge Drive, Grapevine, TX 76501 (US). MCCARTY, Robert, Joseph [US/US]; 7125 Holden Drive, Rockwall, TX 75087 (US).

(74) Agents: MATSIL, Ira, S. et al.; Slater & Matsil, L.L.P., Suite 300, 15150 Preston Road, Dallas, TX 75248 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: POWER CONTROL SYSTEM AND METHOD FOR USE WITH WIRELESS COMMUNICATIONS SYSTEM



(57) Abstract

In method of communicating from a terminal unit (106) to a base unit (102), an incoming signal is sent from the base unit (102) and received a the terminal unit (106). The terminal unit (106) will measure the level of this incoming signal. The terminal unit (106) may also extract digital information from the incoming signal. Based on either the measured signal level, the extracted information or both, the terminal unit (106) will calculate an output power level to use in transmitting a signal back to the base unit (102). An outgoing signal can then be transmitted from the terminal unit (106) using the output power level.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

BNSDOCID: <WO___0064071A2_I_>

Power Control System and Method for Use with Wireless Communications System

CROSS-REFERENCE TO RELATED APPLICATIONS

The following U.S. patents and/or commonly assigned patent applications are hereby incorporated herein by reference:

Patent or Serial No.	Filing Date	Issue Date	Attorney Docket No.
5,787,079 herewith	4/23/96	7/28/98	COM-002

FIELD OF THE INVENTION

The present invention relates generally to power control systems and more particularly to power control systems and methods for use with wireless communications system.

BACKGROUND OF THE INVENTION

Wireless communications are becoming more popular as technology develops. Many people are now communicating through cellular telephones, pagers, radio frequency devices and others. As this trend continues, there is an ongoing need to optimize the communication channel between the two remote communications units.

One issue that arises is the power level that a mobile unit should use to transmit to the base station. In general, the base station has a desired signal level or range of signal levels for incoming communications. This level is determined by, among other things, the output power used by the mobile unit. Therefore, the mobile unit must be able to transmit at a power level compatible with the base station. This level will vary as the mobile unit moves closer to and farther from the base station.

In a well known method, the mobile unit will transmit a first message to the base station at a very low signal level. It will then keep raising the level until a response is received from the

BNSDOCID: <WO__0084071A2_I_>

base station. The reason the mobile unit generally starts at a low level is because if the power level gets too high, the system will lose capacity. After the terminal begins communicating with the base station, the base station may tell the terminal to increase or decrease its power output. With CDMA (code division multiple access), for example, a continuous update signal is provided every millisecond so that the terminal adjusts its output power once a millisecond.

SUMMARY OF THE INVENTION

The preferred embodiment of the present invention discloses a power control method that utilizes both open loop control and closed loop control. An advantageous feature of the preferred embodiment is the ability to automatically control the output gain of the terminal units based upon the strength of the signal received at the base unit. This control can also, or alternatively, be based on the system gain of the base unit and/or a power level increment/decrement signal provided by the base unit.

In one aspect, the present invention describes a method of communicating from a terminal unit to a base unit. An incoming signal is sent from the base unit and received at the terminal unit. The terminal unit will measure the level of this incoming signal. The terminal unit may also extract digital information from the incoming signal. Based on either the measured signal level, the extracted information or both, the terminal will calculate an output power level to use in transmitting a signal back to the base unit. An outgoing signal can then be transmitted from the terminal unit using the output power level.

In another aspect, the present invention provides a method of communicating from a base unit to a terminal unit. In this method, which can be used in conjunction with the method described in the previous paragraph, the base unit transmits a system gain message to the terminal unit. This base unit system gain message includes information regarding the base power output level and/or the desired level of signal to be received from that terminal. At a later time, the base unit will receive a signal from the terminal unit and determine the signal level of

BNSDOCID: <WO___0064071A2_I_>

that signal. Based on that signal level, the base unit will determined a power level increment factor and communicate that factor back to the terminal. The terminal can then use the power level increment factor to adjust its output power for future communications.

The power control techniques of the present invention are particularly useful in systems where the base unit is communicating with multiple terminal units over an FDM (frequency division multiplexed) spectrum, especially a system using sub-bands. In this application, it is important that out-of-band transmissions from one channel or subchannel do not interfere with the base units ability to receive transmissions from sources utilizing adjacent channels or subchannels. To accomplish this goal, it is useful if transmissions from each source are received at about the same signal level. The present invention provides a technique that helps to achieve this objective.

The output gain control functions also provide the advantage of increasing the battery life of the terminal units, as the base unit will continuously monitor the received signal and will instruct the terminal unit to only provide as much output gain as is necessary for signal clarity. In this way, the power consumed by the output circuitry of the terminal unit is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

The above features of the present invention will be more clearly understood from consideration of the following descriptions in connection with accompanying drawings in which:

Figure 1 is block diagram of a communication system of the present invention;

Figure 2 is a frequency domain representation of a first communication channel that can utilize the teachings of the present invention;

Figure 3 is a frequency domain representation of a second communication channel can utilize the teachings of the present invention;

Figures 4a and 4b illustrate the gains and losses of a signal propagating in a communications system;

BNSDOCID: <WO___0064071A2_I_>

Figure 5 is a flow chart of an algorithm that can be used to control the power of a communication unit; and

Figure 6 is a block diagram of a terminal unit.

DETAILED DESCRIPTION

The making and use of the presently preferred embodiments are discussed below in detail. However, it should be appreciated that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

The present invention will be described with respect to a specific embodiment, namely a trunked radio system. The invention also applies, however, to other types of communications systems such as cellular telephones (digital and analog), microwave communications, satellite communications, and others.

Figure 1 illustrates an exemplary radio system 100. System 100 could be a cellular telephone system, a two-way radio dispatch system, a localized wireless telephone or radio system or the like. Base unit 102 can communicate over transmission medium 104 to one or more terminal units 106. Transmission medium 104 represents the wireless communication spectrum. Terminal units 106 can be mobile units, portable units, or fixed location units and can be one way or two way devices. Although only one base unit is illustrated the radio system 100 may have two or more base units, as well as interconnections to other communication systems, such as the public switched telephone network, an internet, and the like. In the preferred embodiment, the system provides for full duplex communications. The teachings of the present invention, however, apply equally to half duplex systems, as well as to time division duplex and other two-way radio systems.

BNSDOCID: <WO___0064071A2_I_>

Further details of a radio system as illustrated in Figure 1 can be found in co-pending application Serial No. 09/295,660 (COM002), which is incorporated herein by reference as if reproduced in its entirety. The present invention could also be used with a system as described in U.S. Patent No. 5,787,079, incorporated herein by reference.

As is well known, radio frequency communications must be transmitted at certain defined frequencies, or more accurately, must be transmitted within defined bandwidths, or channels, centered about defined frequencies. These channels are defined by the appropriate governing authority and are allocated for various spectrum users. In the United States, the Federal Communications Commission (FCC) administers and allocates spectrum usage for non-government users. The NTIA performs a similar function for federal government usage. Other countries have similar organizations.

Radio frequency channels for two-way radio communications are typically defined at 30kHz, 25kHz, or in some cases 12.5kHz wide. Channels of 6.25kHz and 5.0kHz are also in use and it is anticipated that other bandwidth channels may be defined in the future. Out of channel transmissions must be carefully limited in order to prevent transmissions on one channel from interfering with communications on adjacent channels. Channels can be assigned as receive-transmit pairs or as a single frequency.

Figure 2 illustrates an emissions mask for a system using a 25kHz channel. This system can utilize the power control methods of the present invention. The channel is centered about a channel frequency f_0 and extends plus or minus 12.5 kHz on either direction of the center frequency. Note that under FCC regulations, emissions drop off rapidly at the edges of the channel and must be -25 dB at the frequency limits of the occupied channel (i.e. at plus or minus 10 kHz). A typical emissions mask is illustrated by the curves labeled 202, 204 of Figure 2. Note that the entire available channel, less reserved portions for guard-bands, is occupied by a single, roughly 20kHz wide signal, representing a single communication path between a base unit and a terminal unit.

BNSDOCID: <WO___0064071A2_I_>

In the preferred embodiment, the system is a time domain multiplexed (TDM) system. At any given time (e.g., a first TDM time slot), a first terminal unit has access to the channel and only it may transmit to the base unit (on that channel). No other transmission can occur at these frequencies at this time. The transmissions from the first terminal unit are illustrated (in the frequency domain) by the curve 206.

For a TDM system, a second terminal unit has access to the channel during a second time slot and only it may transmit to the base unit (on that channel) at that time. During this second time period, the first terminal unit may not transmit. In this way, contention between the first and second terminal units is prevented. Note that during the second time period although the first terminal unit may not transmit, it may receive transmission from the base unit being transmitted over the forward channel (on a different frequency channel). Likewise, the second terminal unit may receive transmissions from the base unit during the first time period, although it may not transmit during this time.

For a typical 25kHz channel, up to a maximum of 20kHz is available for signal transmission (the remaining 5 kHz being reserved for guard-banding.) Currently the maximum practical data rate for a 20 kHz channel is 64kbits/sec (using a 16 QAM system). Assuming the normal data rate of the signal to be transmitted (as a function of the vocoder, the forward error correction, and miscellaneous control over head bits) is 8 kb/s, the maximum number of time slots that could be transmitted over the channel would be eight. This is because the signal would need to be transmitted at eight times the normal rate (i.e. at 64 kb/s) during the one eighth of the time allocated to each communication path. In many systems, at least one time slot is reserved for control signals, which would further limit the number of time slots available for voice signal transmission. As technology advances, improved vocoders and other system components may make possible acceptable signal quality at lower data rates. An advantage of the preferred embodiments is the ability to adjust the number of time slots, length of time slots, and the like, as the capabilities of system components advance.

BNSDOCID: <WO___0064071A2_I_>

Figure 3 illustrates an emissions mask for a 25 kHz channel that has been divided into separate sub-channels. In the preferred embodiment, the FCC defined 25 kHz channel is divided into four sub-channels of 4 kHz each. The sub-channels are separated from each other by 800 Hz guard-bands, and the channel has guard-bands on the sides as well to prevent inter-channel interference.

In the preferred embodiment the center of sub-channel A is offset from the center frequency of the channel by –7.2 kHz, i.e. the sub-channel is 4 kHz wide and is centered about a frequency offset from the channel frequency f_0 by –7.2 kHz. The center of sub-channel B is offset from the center frequency by –2.4 kHz, the center of sub-channel C is offset by 2.4 kHz and the center of sub-channel D by 7.2 kHz, as shown.

Sub-channels A, B, C, and D are illustrated by frequency domain curves 302, 304, 306, and 308, respectively in Fig. 3. Note that out-of-band emissions are also illustrated in Fig. 3, as curves 310 and 312. These curves represent noise as well as side-band signals associated with the four sub-channels A-D. Such noise and side-band signals also occur within the four sub-channels A-D, but will not interfere with the desired signal, provided the signal to noise ratio is adequate.

Each sub-channel corresponds to an available communication path between the base unit 102 and a terminal unit 106. More accurately, in the preferred embodiment, because of time division multiplexing, each sub-channel is time divided into two time slots for voice or data traffic, hence each sub-channel represents two communication paths. In this way, up to eight separate communication paths can be established on a standard 25 kHz channel. In fact, as shown, the four sub-channels and sufficient guard-banding only occupy about a 20 kHz bandwidth. Note that, even without TDM, up to four communications paths can be established on a single 25 kHz channel. As will be apparent to one skilled in the art, the teachings of the preferred embodiments can be applied to other organizations, such as additional time slots and/or narrower (or wider) sub-channels as permitted by the desired data rates and capacity needs.

BNSDOCID: <WO__0064071A2_I_>

Note that the signal being carried on sub-channel C is shown as being weaker (lower magnitude) than the signal on adjacent sub-channels B and D. This may be because the terminal unit transmitting on sub-channel C is further away from the receiving base unit than the terminal units transmitting on the adjacent sub-channels. In order to prevent a sub-channel's signal from being swamped out by the side-band signals of the adjacent sub-channels, guard-bands are employed. In the preferred embodiments, the sub-channels are separated by 800 Hz guard-bands.

Additionally, as will be discussed in greater detail below, the system 100 employs a transmission gain feedback loop between the base unit and the terminal units. When the base unit detects that a terminal unit's signal is weak relative to the signals received on the other sub-channels, the base unit will instruct the terminal unit to increase its transmission gain, as will be discussed in more detail below. The value used to instruct the terminal to increase its gain is sent during one time slot and implemented in the next time slot. Accordingly, the output power of the terminal can be adjusted once in a time slot, e.g., every 60ms.

One advantageous feature of the preferred embodiment is the ability to automatically control the output gain of the terminal units 106 based upon the strength of the signal received at the base unit 102. As discussed above, it is necessary to keep the signal level of the signals received on the sub-channels approximately equal (or as near to equal as possible) to minimize the interference between sub-channels.

Returning to Figure 3, this drawing presents an idealized signal where the entire energy of a given signal is contained within its 4 kHz bandwidth. In reality, considerable energy is also transmitted outside the 4 kHz bandwidth. Even with guard-bands, some energy from one sub-channel will be transmitted in the bandwidth of the adjacent sub-channel. This out-of-band energy is typically highly attenuated with respect to the in-band energy, typically on the order of minus 20 dB relative to the in-band energy. If the signal being received on sub-channel A is as strong as the signal being received on sub-channel B, for instance, then the interference caused

BNSDOCID: <WO___0064071A2_I_>

by out-of-band transmissions from sub-channel B, being 20 dB down, would not cause significant interference with signal reception on sub-channel A.

Note in Figure 3, however, the signal being received on sub-channel C is considerably weaker than the signal being received on sub-channel D (and sub-channel B as well). The weak signal on sub-channel C is much more susceptible to the interference caused by the out-of-band transmissions from sub-channels B and D. To compensate for this a gain control feedback loop is established between the base unit and the terminal units.

The present invention describes both open loop and closed loop control measures, either of which can be used to control the power output from the terminal unit 106. In fact, in the preferred embodiment both open loop and control loop power control are utilized to regulate the power outputs of the various terminals transmitting on a given channel. Open loop control will be described first.

In open loop power control, the terminal unit 106 measures the level of the signal received from the base station 102 and adjusts its power output dependent on this received signal level.

As discussed above, the goal of power control is to keep all of the sub-channels at the same amplitude. This task is made more difficult by the fact that each of the four sub-channels A, B, C and D (see Figure 3) are transmitted from four different terminal units 106 at any given time. To complicate matters, none of the terminal units 106 have any information regarding the other units, which may be closer or further from the base unit 102. Despite these difficulties, it is desirable that signals on each channel be received at the base unit 102 at the same predetermined level.

Figures 4a and 4b illustrate a simplified version of a radio communication system. These diagrams are used to illustrate the variations in signal strength as a signal propagates from the base unit 102 to the terminal 106 (Figure 4a) and from the terminal 106 back to the base unit 102 (Figure 4b). The factors that affect signal level are summarized in Table 1 and will be used to set the initial output signal level for the terminal unit 106.

BNSDOCID: <WO__0064071A2_I_>

Table 1

Item	Abbreviati n	Where from
Base Power Output (one subchannel)	BPO	Known
Base Transmit Antenna System Gain	BTA	Known
Base to Terminal Path Loss	BTPL	Unknown
Terminal Receive Antenna System Gain	TRA	Known
Terminal Receive Signal Level	TRSL	Measured
Terminal Power Output	TPO	Calculated
Terminal Transmit Antenna System Gain	TTA	Known
Terminal to Base Path Loss	TBPL	Unknown
Base Receive Antenna System Gain	BRA	Known
Base Receive Signal Level	BRSL	Desired

Referring first to Figure 4a, a signal is transmitted from the base unit 102 at a given power level. This power level is referred to as the base power output (BPO). The BPO is a known quantity provided by base unit 102. The BPO is a measure of the output power for a single subchannel. In the preferred embodiment, this value may range between about +20dBm and about +46dBm.

The signal is transmitted from the base unit 102 via an antenna 112. The antenna 112 has an associated gain noted as the BTA (Base Transmit Antenna system gain). The BTA encompasses not only the antenna gain but also other factors such as losses in coaxial cables between antenna 112 and unit 102. This is also a quantity that can be communicated to the terminal unit 106.

From the antenna 112, the signal will propagate to the terminal unit antenna 114. While traveling through the air, the signal will experience a loss referred to as the Base-to-Terminal Path Loss (BPTL). The BPTL is an unknown quantity that will vary depending upon factors such as the

BNSDOCID: <WO___0064071A2_I_>

path length, weather conditions and obstacles between the transmit and receive antennas 112 and 114. Since the terminal unit may be mobile and other conditions may change, the BPTL may also vary over time.

The signal will finally be received at the terminal unit, passing through antenna 114. Terminal unit antenna 114 will contribute a gain (or loss) noted by the Terminal Receive Antenna system gain (TRA). The level of the signal received at the terminal unit 114 is referred to as the Terminal Received Signal Level (TRSL). This quantity can be measured by terminal unit 106.

Considering the signal levels and gains (or losses) illustrated in Figure 4a, a base-to-terminal link equation can be formulated as follows.

(1) $TRSL = BPO + BTA - BTPL + TRA$

A similar analysis can be performed for a signal traveling from the terminal unit 106 to the base unit 102 as shown in Figure 4b. In this case, a signal output from the terminal unit 106 will have a Terminal Power Output (TPO) as set by the terminal unit 106. The terminal unit antenna 114 will contribute a known Terminal Transmit Antenna system gain (or loss) TTA. The signal will then experience an unknown Terminal-to-Base Path Loss TBPL as it propagates from terminal unit 106 to base unit 102. After the base unit antenna 112 contributes a known Base Receive Antenna system gain BRA, the signal is received at the base unit with a Base Receive Signal Level (BRSL). In the preferred embodiment of the invention, the desired BRSL is typically between about -115dBm and -80dBm, preferably about -95 dBm.

As before, a path link equation can be determined.

(2) $BRSL = TPO + TTA - TBPL + BRA$

The goal here is to set the signal level received at the base unit 102 (BRSL) to a predetermined level. The lone variable that can be controlled is the level of power output from the terminal 106, i.e., the TPO.

Reviewing the path link equations (1) and (2), it can be seen that the two equations have three unknowns, namely BTPL, TBPL and TPO. To solve these equations, an assumption is

BNSDOCID: <WO___0084071A2_I_>

therefore made that the path loss from the base unit 102 to the terminal unit 106 is the same as the path loss in the return path, i.e., from the terminal unit 106 to the base unit 102. This assumption is generally fairly accurate and leads to a third equation.

(3) $$BTPL = TBPL$$

Now, having three equations with three unknowns, the terminal power output (TPO) can be calculated through straightforward algebra. In particular, the terminal power output can be calculated as

(4) $$TPO = BRSL - TTA + BPO + BTA + TRA - TRSL - BRA$$

It is noted that each of the components in the sum are known, the antenna system gains TTA, BTA, TRA and BRA because they are fixed quantities for a given system, the base power output BPO because it is set by the base unit, the terminal receive signal level TRSL because it is measured by the terminal, and the base receive signal level BRSL because it has been preselected.

To simplify equation (4), some of the components can be combined and renamed as follows.

(5) $$\text{Terminal System Gain} = TSG = TRA - TTA$$

(6) $$\text{Base System Gain} = BSG = BRSL + BPO + BTA - BRA$$

This leads to a simplified version of the equation for Terminal Power Output.

(7) $$TPO = \text{Base System Gain} + \text{Terminal System Gain} - TRSL$$

The Terminal System Gain is generally about zero. Even if it is not, the value will be known to terminal unit 106. The Base System Gain is a measure of the conversion gain of the base station and will vary with different base stations. It may also vary for a given base station, for example if the output power level changes or if the base station can select between multiple antennas to transmit with. This quantity will be provided to the terminal unit by the base system and can vary with different base units.

As can be seen from Equation (7), the terminal unit 106 uses two factors (when TSG is zero) to determine the power level it transmits at initially, namely the base system gain and the signal level it receives. The base system gain is sent to the terminal. This value can be changed from time

BNSDOCID: <WO___0064071A2_I_>

to time, for example when the base unit uses a different power output or decides that a different receive signal level is desirable. The value may also change as the terminal unit roams and changes the base unit with which it communicates. The base system gain will generally be sent periodically. To save bandwidth, the BSG does not need to be sent every slot since it does not change that often.

In this technique, the terminal receives information from the base unit in two ways. First, it measures the level of the received signal. This can be performed using well known techniques. Second, it demodulates and decodes the received signal to extract information (e.g., the base system gain) being communicated from the base unit.

The open loop power control can be understood further by use of a numerical example as listed in Table 2. The numbers provided by this table are selected as exemplary values but it is understood that these values will vary based on system design and operating conditions.

Table 2

Parameter		Value	Where from
Base Receive Signal Level	BRSL	-98 dBm	set by the system requirements
Base Power Output	BPO	+43 dBm	set by base unit
Base Transmit Antenna System Gain	BTA	+ 3 dB	known
Base Receive Antenna System Gain	BRA	+ 6dB	known
Terminal Receive Antenna System Gain	TRA	+ 1 dB	known
Terminal Transmit Antenna System Gain	TTA	+1dB	known
Terminal Receive Signal Level	TRSL	- 95 dBm	measured at terminal
Base System Gain	BSG	-58 dB	calculate as BRSL + BPO + BTA - BRA
Terminal System Gain	TSG	0	calculate as TRA - TTA
Terminal Power Output	TPO	+ 37 dBm	calculate as BSG + TSG - TRSL

Implementation of the above equation (7) provides open loop power control. This formula was based on an assumption that the two path losses are the same. As long as this assumption remains valid, the terminal can easily calculate its output power level and the proper level signal will be received at the base station. There are times, however, when this assumption is not necessarily valid. In those cases, closed loop power control can be used.

Open loop power control provides an initial power output level for the terminal unit 106. A terminal unit that has not communicated with the base station for a long period of time will calculate a TPO and send a message to the base station to request a channel. The base station will measure

BNSDOCID: <WO__0064071A2_I_>

the signal level received from the terminal and compare it to the preselected target level. If the measured received signal level is different than the target level, e.g., because the path losses are different, the base unit will send a correction factor. The base unit will continue adjusting the terminal's signal level as necessary for each communication.

In the preferred system, three bits are used to adjust the signal level. These three power control increment bits are provided during each slot and are used by the base unit to transmit output gain feedback to the terminal units. The base unit monitors the received signal strength of the terminal units and sends a power control increment instruction back to either increase output power gain, decrease output gain, or leave the gain level unchanged. In a preferred embodiment, three power control bits are decoded as indicated in Table 3. Other numbers of bits and other increment values could alternatively be used.

Table 3

010	+ 6 dB
000	+ 4 dB
011	+ 2 dB
110	0 (no change)
001	- 2 dB
100	- 4 dB
111	- 6 dB
101	- 8 dB

In the preferred embodiment, both open loop and closed loop control are used simultaneously. In other words, the terminal unit will adjust its transmit power output continuously based on the received signal level and the increment/decrement messages received from the base unit. There is an advantage to continuously monitor the received signal level in that the system can get faster response by supplementing the increment/decrement messages.

In an alternate embodiment, the terminal unit may determine its initial value with open loop control and then adjust the power output solely on the basis of closed loop control. This method can have a disadvantage for mobile units. For example, if an obstruction is removed from between the terminal unit and the base unit, the proper terminal output power may vary significantly in a short

BNSDOCID: <WO___0064071A2_I_>

period of time. Using only increment and decrement signals, it could take a number of time slots until the proper signal level is restored. When the received power is monitored, however, the terminal will detect that the path loss has changed significantly and adjust its power accordingly. This adjustment can lead to faster response time.

Figure 5 illustrates a flow chart 500 showing the control algorithm of the preferred embodiment. In this algorithm, the system maintains some historical signal level information. This information is combined, using given weighting factors, with the newly measured received signal level to determine the transmit level. If the received information changes by a large amount then the transmit level will also change by a relatively large amount.

In first step 502, the system determines how much time has passed since the last transmission. If the terminal unit has not communicated with the base unit in a long time, then all prior power control increment commands will be ignored. For example, the terminal unit may determine if a transmission has occurred within the last 1000 time slots (T=1000). If each time slot is 30ms, this would equate to 30 seconds. The optimum value of T can be determined by field testing.

If the terminal has not communicated with the base station within T slots, the terminal power output TPO will be calculated using the open loop formula. This step is indicated by step 504 where BSG is the base system gain (received from the base station), TSG is the terminal system gain (known at the terminal unit), and FTRSL is the filtered terminal receive signal level (measured by the terminal unit). Since the terminal is generally on at all times, it constantly receives transmissions from the base station. Each (or some portion) of these transmissions can be measured and used as the FTRSL for step 504. The terminal power control increment TPCI will also be initialized to zero in step 506.

During the next power calculation, the algorithm will move to step 508, assuming too much time has not passed. At this point, the terminal power output TPO will be calculated using a filtered terminal receive signal level (FTRSL) that is the weighted average of the current measured received

BNSDOCID: <WO___0064071A2_I_>

signal level and the historical signal level. In particular, the filtered terminal receive signal level can be calculated as

$$FTRSL(k) = A*TRSL(k) + B*FTRSL(k-1) \quad (8)$$

where k is the current time slot, k-1 is the previous time slot, and A and B are weighting factors (A+B=1). As an example, the weighting factors may be set as A=0.1 and B=0.9 so that the TPO formula uses a received signal level that is heavily weighted by the historical value. Empirical testing can be used to determine the optimum weighting factors A and B. TRSL(k) is the measured terminal receive signal level for the current time slot.

The terminal power output TPO is also based on the terminal power control increment TPCI, which provides the closed loop control. This factor is cumulative so that past increment and decrement signals from the base station are included. Using the increment signals in Table 2 as an example, the base station can tell the terminal to increment by 10dB by having it increment by 6dB in the first time slot and 4dB in the next time slot. The terminal power control increment can be written as a formula where

$$TPCI(k) = PCI(k) + TPCI(k-1) \quad (9)$$

where PCI(k) is the power control increment value sent by the base station at time k and TPCI(k) and TPCI(k-1) are the cumulative power control increment values at the current time slot and the previous time slot, respectively.

As in the open loop equation, BSG is the base system gain and TSG is the terminal system gain.

As discussed above, an alternate embodiment utilizes open loop control during the initialization process only. An algorithm of this embodiment could be illustrated by a flowchart that is the same as Figure 5 except that the FTRSL term of the TPO calculation in step 508 is fixed by the initial calculation, e.g., in step 504. In this embodiment, the system could initially fix BSG, FTRSL or both the first time through and then make all adjustments based on TCPI. In this case, steps 504 and 506 provide the open loop control and step 508 provides the closed loop control.

BNSDOCID: <WO___0064071A2_I_>

In yet another embodiment, as noted above, the terminal may use only open loop control. In that case, the algorithm would repeat step 504 each time slot that power adjustment is activated. This last method is not generally preferred, however, since the terminal unit would have difficulty compensating if the signal level received back at the base station is too low. This problem could be overcome if the base station lowers its output power level upon detecting a low power level from the terminal. This adjustment would lead to a lower level received signal at the terminal unit, which would adjust by raising the power level.

In an alternate embodiment, the system can compensate for the situation when the terminal cannot increase its transmission gain. If this is the case, the base station can instruct terminals operating at each of the other sub-channels to lower their output power so that the signal level received at the base station will be about equal for each sub-channel. Referring to Figure 3 as an example, the base station would instruct the terminals operating at sub-channels A, B and D to lower their output power. In this manner, each of the sub-channels A, B, C and D would be closer to the same level.

A potential problem with this embodiment is that the system determines the optimal received power based on a tradeoff between receiving a high signal level at the base unit (to maximize signal-to-noise ratio and therefore minimize bit error rate) and transmitting at a lower power level from the terminal (to save battery life). Lowering the signal for the sub-channels, may increase the bit error rate for all of the sub-channels. Therefore, a tradeoff must be made between lowering the SNR for all sub-channels and accepting energy spillover in the sub-channel that has the low signal level.

There are a number of ways to implement this alternate embodiment. For instance, the terminal unit can transmit a message to the base unit indicating its power level. As an example, a two bit message could be interpreted as: 00-transmitting at minimum power, 01-transmitting at less than 50% power, 10- transmitting at greater than 50% power, and 11-transmitting at maximum power. Alternatively, or in addition, the base unit can monitor the power received from the

BNSDOCID: <WO___0064071A2_I_>

terminal. If the received signal level remains low after sending a number of instructions increase the terminal output power, the base may assume that the terminal power is already at maximum.

The concepts behind the alternate embodiment could also be implemented in the other direction. If the base unit observes that all of the terminals are transmitting below their maximum power level, the base unit might decide to increase the power level on all of the terminals to reduce received errors. This embodiment may be useful, for example, when the base unit determines that an error rate associated with the transmissions for the terminals is too high. This error rate might be an average error rate for all of the terminals or an error rate for just one (or some) of the terminals.

A simplified block diagram of a terminal unit 106 is illustrated in Figure 6. A receiver/transmitter 120 is coupled to terminal antenna 114. Accordingly, an incoming signal will be received at receiver/transmitter 120. Receiver/transmitter may include a number of components such as frequency shifters, A/D and D/A converters, modulators and demodulators, filters and others. Specific details of a preferred receiver/transmitter 120 are provided in co-pending application Serial No. 09/295,660 (COM002).

The incoming signal will be provided to a level measurement unit 122. The level measurement unit 122 will receive this analog signal and measure the amplitude, that is the signal level. In the preferred embodiment, this task is accomplished by a digital signal processor that computes I2 and Q2 (in-phase component and quadrature-phase component) for a number of samples for each signal. For example, each symbol period can be sampled eight times within the period. If 120 symbols are transmitted in each time slot, then the signal level would be derived from 960 samples in each time slot.

The incoming signal is also provided to an extraction unit 124. The purpose of the extraction unit is to extract digital information from the incoming signal. This digital information can include the base system gain BSG and/or the power control increment message, both of which were discussed above. The extraction unit 124 de-interleaves the control bits from

BNSDOCID: <WO___0064071A2_I_>

the total bit stream so that the control bits can be interpreted. Once again, details on extracting information from an incoming signal are provided in the co-pending application.

Both the level measurement unit 122 and the extraction unit 124 provide information to a power control unit 126. In the preferred embodiment, this information is provided in the form of digital signals. The power control unit 126 takes the incoming information and calculates the transmit power output TPO. For example, the power control unit 126 may comprise a processor, e.g., a microprocessor and/or a digital signal processor, that executes an algorithm as detailed in Figure 5.

The power control unit 126 includes an output coupled to receiver/transmitter 120. Output power information, e.g., the transmit power output TPO, can be provided to the receiver/transmitter along this line. As an example, the terminal power can be controlled digitally. In this case, a digital word instructs the terminal to produce one of a number of different power levels. For example, if there are 30 different power levels that are each 2dB apart, the terminal would have a 60dB range. This task could also be accomplished using an analog signal or with a different number of steps or step differences. As described above, the output power information will based on the information received from the extraction unit 124 and the level measurement unit 122.

Throughout the detailed description as provided above, reference is made to the signal level, for example the base receive signal level (BRSL) or the transmit receive signal level (TRSL). As discussed above, this level can be measured in terms of absolute signal level, e.g., a voltage received at the appropriate location. Alternatively, the signal-to-noise ratio can be used in place of the signal level. It is intended that all references to signal level, including in the claims, include both absolute signal level and signal-to-noise ratio.

In fact, using the signal-to-noise ratio provides some advantage in that this is the value that truly affects system performance. Even if the absolute signal level is low, the system performance will not be degraded if the signal-to-noise ratio is high enough.

BNSDOCID: <WO___0064071A2_I_>

Signal-to-noise ratio can be measured in a number of ways such as by approximation from the bit error rate. For example, the system could monitor the cyclic redundancy code (CRC) and estimate signal-to-noise ratio from the number of errors detected. Alternatively, or in addition, convolutional encoding and Viterbi decoding can be used to estimate the error rate. With this technique, the signal is convolutionally encoded at the transmitter and sent to the receiver. At the receiver, the signal is decoded and then re-encoded. The error rate can then be estimated by comparing the re-encoded data with the received data.

While being described so far in terms of a radio frequency system, the present invention also applies to a number of different applications. For example, the present invention could be applied to cable modems, two way fiber optic links, and point-to-multipoint microwave systems.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

BNSDOCID: <WO___0064071A2_I_>

WHAT IS CLAIMED IS:

1. A method of communicating from a terminal unit to a base unit, the method comprising:

receiving an incoming signal at the terminal unit, the signal being from the base unit;

extracting a base system gain message from the incoming signal;

determining an output power level based on the extracted base system gain message; and

transmitting an outgoing signal from the terminal unit, the outgoing signal being transmitted at the output power level determined based on the extracted base system gain message.

2. The method of claim 1 and further comprising determining information regarding a signal level of the incoming signal, wherein the output power level is further determined based on the information regarding the signal level of the incoming signal base system gain message.

3. The method of claim 1 wherein the base system gain message includes information regarding the output power level of the base unit.

4. The method of claim 1 wherein the base system gain message includes information regarding the signal level of a signal received at the base unit from the terminal unit.

5. The method of claim 1 wherein the base system gain message includes information regarding an antenna gain of at least one antenna located at the base unit.

6. The method of claim 1 and further comprising extracting a power level increment message from the incoming signal, wherein determining an output power level is further based on the power level increment message.

BNSDOCID: <WO___0064071A2_I_>

7. The method of claim 6 wherein the power level increment message comprises a multi-bit message.

8. The method of claim 7 wherein the power level increment message comprises a three bit message, the three bits defining eight power level increment choices.

9. The method of claim 8 wherein the eight power level increment choices comprise +6dB, +4dB, +2dB, 0dB, -2dB, -4dB, -6dB and -8dB.

10. The method of claim 1 wherein the output power level is further determined based on a terminal system gain.

11. The method of claim 1 wherein extracting a base system gain message comprises extracting a base system gain message and a power level increment message from the incoming signal, wherein the output power level is further determined based on both the base system gain message and the power level increment message.

12. The method of claim 1 and further comprising measuring the signal level of the incoming signal, wherein the output power level is determined by both the measured incoming signal level and a historical incoming signal level, the historical incoming signal level being determined by maintaining information regarding measured incoming signal levels from prior incoming signals.

13. The method of claim 12 wherein the output power level is determined by taking a weighted average of the measured incoming signal level and the historical incoming signal level.

BNSDOCID: <WO___0064071A2_I_>

14. The method of claim 13 wherein the output power level is determined by adding about ten percent of the measured incoming signal level and about ninety percent of the historical incoming signal level.

15. A method of communicating from a base unit to a terminal unit, the method comprising:

transmitting a base unit system gain message to the terminal unit, the base unit system gain being transmitted at a base power output level, the base unit system gain message including information regarding the base power output level;

receiving a signal at the base unit from the terminal unit;

determining a level of the signal received at the base unit from the terminal unit;

determining a power level increment factor based upon the determined level of the signal received at the base unit from the terminal unit; and

transmitting a power level increment message to the terminal unit, the power level increment message including the power level increment factor.

16. The method of claim 15 wherein the base unit system gain message further includes information regarding the level of a signal received at the base unit from the terminal unit.

17. The method of claim 15 and further comprising transmitting a second base unit system gain message to a second terminal unit, the second base unit system gain message being different than the base unit system gain message transmitted to the terminal unit.

18. A method of communicating from a terminal unit to a base unit, the method comprising:

receiving at least one incoming signal at the terminal unit, the at least one incoming signal being from the base unit;

determining information regarding a signal level of the at least one incoming signal;

BNSDOCID: <WO___0064071A2_I_>

extracting system gain information from the at least one incoming signal;

determining a terminal output power level based on the information regarding the signal level and the system gain information;

transmitting an outgoing signal from the terminal unit, the outgoing signal being transmitted at the terminal output power level;

receiving a second incoming signal at the terminal unit, the second incoming signal being sent from the base unit after the outgoing signal is transmitted;

extracting power level increment information from the second incoming signal;

determining a second terminal output power level based at least in part on the power level increment information; and

transmitting a second outgoing signal from the terminal unit, the second outgoing signal being transmitted at the second terminal output power level.

19. The method of claim 18 and further comprising measuring a signal level of the second incoming signal, wherein the second output power level is determined based at least in part upon the measured second incoming signal level.

20. The method of claim 18 wherein the system gain information includes information relating to a base output power level of the at least one incoming signal.

21. The method of claim 20 wherein the system gain information further includes information relating to a desired signal level of a signal received at the base unit from the terminal unit.

22. A terminal unit comprising:

a receiver/transmitter;

BNSDOCID: <WO___0064071A2_I_>

a level measurement unit having an analog input coupled to the receiver/transmitter, the level measurement unit to determine the signal level of a signal received at the receiver/transmitter;

an extraction unit including a analog-to-digital converter, the analog-to-digital converter having an analog input coupled to receiver/transmitter; and

a power control unit including first and second digital inputs, the first digital input coupled to an output of the level measurement unit and the second digital input coupled to an output of the extraction unit, the power control unit further including an output coupled to the receiver/transmitter, the power control unit to provide output power information to the receiver/transmitter, the output power information based on digital information received at the first and second digital inputs.

23. The unit of claim 22 wherein the level measurement unit, the extraction unit, and the power control unit are implemented in a digital signal processor.

24. The unit of claim 22 wherein the signal level of the signal received at the receiver/transmitter is determined in terms of a signal-to-noise ratio.

25. A terminal unit comprising:

means for receiving a signal from a base unit;

means for measuring the signal level of the signal received from the base unit;

means for extracting information from the signal received from the base unit;

means for determining an output power level based on the signal level of the signal received from the base unit and also based on the information extracted from the signal received from the base unit; and

BNSDOCID: <WO___0064071A2_I_>

means for transmitting an outgoing signal, the outgoing signal being transmitted at the output power level based on the signal level of the signal received from the base unit and also based on the information extracted from the signal received from the base unit.

26. A method of communicating with a plurality of terminal units on adjacent frequency channels, the method comprising:

receiving a transmission from a first one of the terminal units, the transmission being at a low signal level relative to transmissions from at least one other of the plurality of terminal units;

determining that the first one of the terminal units is unable to transmit at an increased power level; and

instructing the at least one other of the plurality of terminal units to transmit at a decreased power level.

27. The method of claim 26 wherein determining that the first one of the terminal units is unable to transmit at an increased power level comprises receiving a message from the first one of the terminal units that it is transmitting at a maximum power level.

28. The method of claim 26 wherein determining that the first one of the terminal units is unable to transmit at an increased power level comprises sending messages to the first one of the terminal units and determining a signal level of a signal received from first one of the terminal units is not increasing.

29. A method of communicating with a plurality of terminal units on adjacent frequency channels, the method comprising:

receiving a transmission from each of the plurality terminal units;

determining an error rate associated with the transmissions from each of the plurality of terminal units;

BNSDOCID: <WO___0064071A2_I_>

determining whether any of the terminal units are transmitting at a maximum power level; and

if none of the terminal units are transmitting at a maximum power level, instructing each of the plurality of terminal units to increase their transmission power level.

30. The method of claim 29 wherein determining whether any of the terminal units are transmitting at a maximum power level comprises receiving a message from each of the terminal units, the message including information about transmission power level.

31. The method of claim 26 wherein determining whether any of the terminal units are transmitting at a maximum power level comprises sending messages to each of the terminal units and determining whether the level of signals received from each of the terminal units is increasing.

BNSDOCID: <WO___0064071A2_I_>

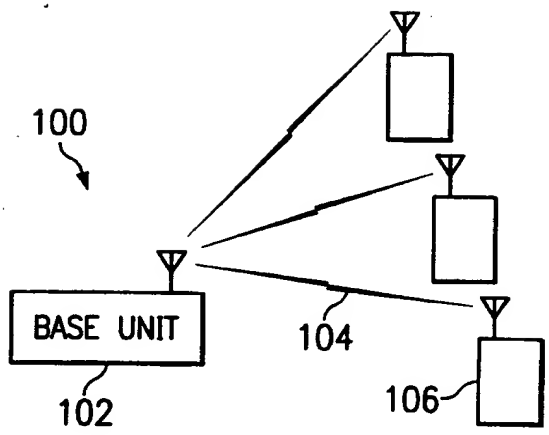


FIG. 1

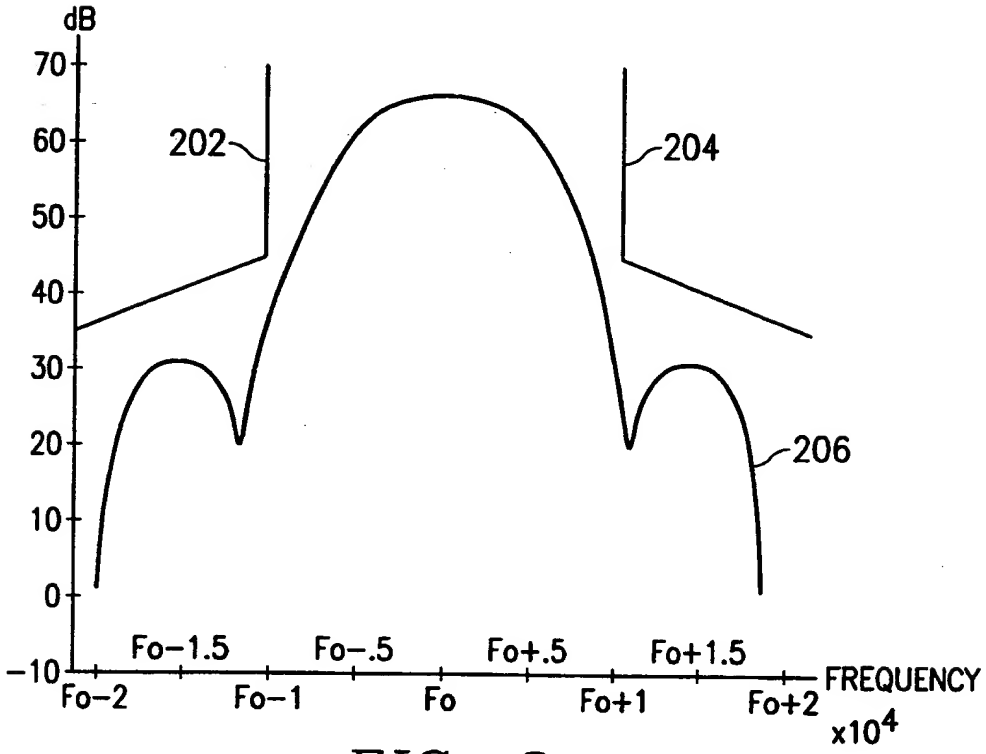


FIG. 2

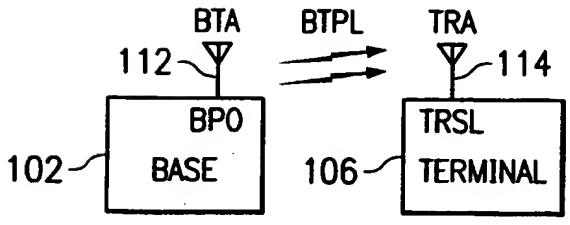


FIG. 4a

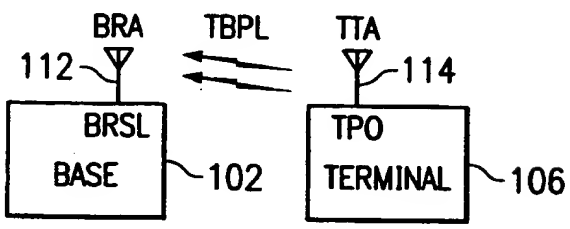


FIG. 4b

BNSDOCID: <WO___0064071A2_I_>

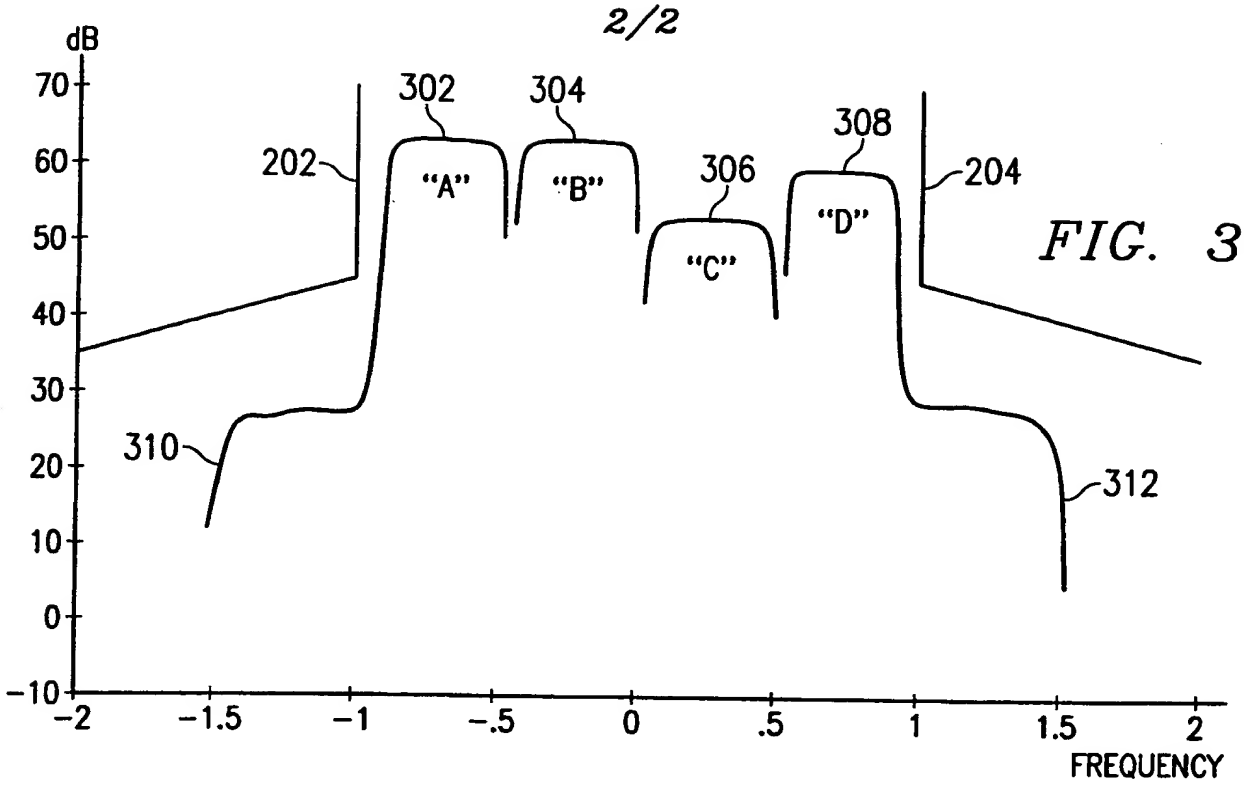


FIG. 3

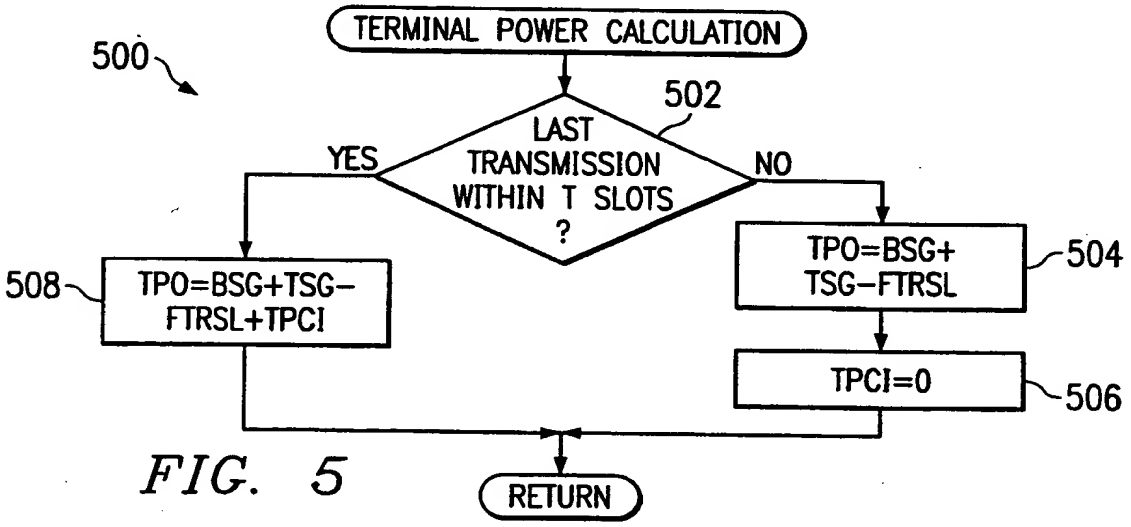


FIG. 5

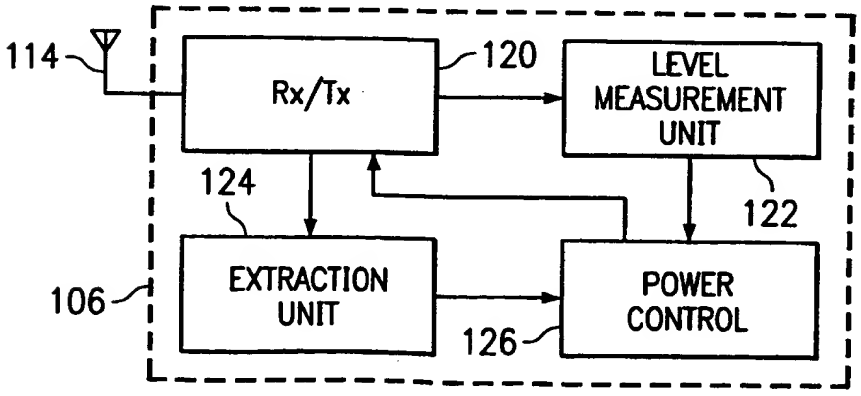


FIG. 6

THIS PAGE BLANK (USPTO)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 October 2000 (26.10.2000)

PCT

(10) International Publication Number
WO 00/64071 A3

(51) International Patent Classification[7]: H04B 7/005

(21) International Application Number: PCT/US00/10238

(22) International Filing Date: 18 April 2000 (18.04.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/296,055 21 April 1999 (21.04.1999) US

(71) Applicant *(for all designated States except US)*: **COMSPACE CORPORATION** [US/US]; Suite 100, 955 Freeport Parkway, Coppell, TX 75019-4415 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BARTELME, Joseph, Peter** [US/US]; 2111 Lakeridge Drive, Grapevine, TX 76501 (US). **MCCARTY, Robert, Joseph** [US/US]; 7125 Holden Drive, Rockwall, TX 75087 (US).

(74) Agents: **MATSIL, Ira, S.** et al.; Slater & Matsil, L.L.P., Suite 300, 15150 Preston Road, Dallas, TX 75248 (US).

(81) Designated States *(national)*: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW.

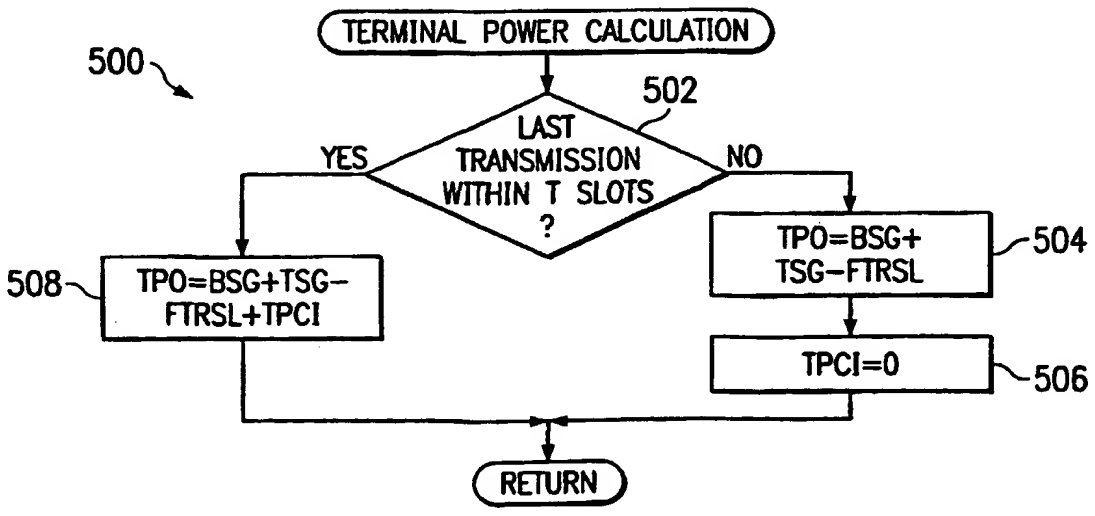
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

(88) Date of publication of the international search report:
26 April 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: POWER CONTROL SYSTEM AND METHOD FOR USE WITH WIRELESS COMMUNICATIONS SYSTEM



(57) Abstract: In method of communicating from a terminal unit (106) to a base unit (102), an incoming signal is sent from the base unit (102) and received a the terminal unit (106). The terminal unit (106) will measure the level of this incoming signal. The terminal unit (106) may also extract digital information from the incoming signal. Based on either the measured signal level, the extracted information or both, the terminal unit (106) will calculate an output power level to use in transmitting a signal back to the base unit (102). An outgoing signal can then be transmitted from the terminal unit (106) using the output power level.

WO 00/64071 A3

BNSDOCID: <WO___0064071A3_I_>

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 00/10238

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 869 626 A (ALSTHOM CGE ALCATEL) 7 October 1998 (1998-10-07) column 2, line 5-46 column 6, line 28 -column 7, line 3 column 7, line 43-46	26-31

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2000	02 01 2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Yang, Y

1

Form PCT/ISA/210 (second sheet) (July 1992)

BNSDOCID: <WO___0064071A3_I_>

INTERNATIONAL SEARCH REPORT

In. .ational application No.
PCT/US 00/10238

Box I Observations where c rtain claims were found unsearchabl (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

B x II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

BNSDOCID: <WO___0064071A3_I_>

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14, 15-17, 18-21, 22-24, 25

Method of communicating from a terminal unit to a base unit and terminal unit using this method, where the terminal unit's ouput power level is determined based on extracting a base gain message from the incoming signal and on the measured signal level of the incoming signal, said incoming signal being received at the terminal unit.

2. Claims: 26-31, 29-30

Method of communicating with a plurality of terminal units on adjacent frequency channels, where

1) upon detecting that a first one of the plurality of terminal units is unable to transmit at an increased power level, a base unit instructs at least one other of the plurality of terminal units to transmit at a decreased power level;

2) upon determining that none of the plurality of terminal units are transmitting at a maximum power level, a base unit instructs each of the plurality of terminal units to increase their transmission power level.

BNSDOCID: <WO___0064071A3_I_>

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Interr ...al Application No
PCT/US 00/10238

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0869626 A	07-10-1998	FR 2761838 A	09-10-1998
		AU 5968198 A	08-10-1998
		JP 10285110 A	23-10-1998

Form PCT/ISA/210 (patent family annex) (July 1992)

BNSDOCID: <WO___0064071A3_I_>

THIS PAGE BLANK (USPTO)